CEMENT AND LIME MANUFACTURE

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Testing Cement Briquettes.

THE following paper by Professor Paul Cloke, Dean of the College of Technology of the University of Maine, and Professor W. S. Evans, Head of the Department of Civil Engineering of the same University, is reprinted from the Bulletin of the American Society for Testing Materials for May, 1940.

Anyone testing cement briquettes will observe that in a large number of cases the briquette does not break at its smallest section as it was designed to do but breaks somewhere in the enlarged portion and frequently at the point of contact

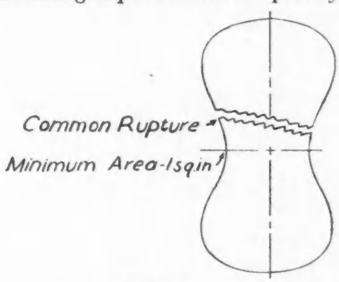

Fig. 1.

with one of the grips (see *Fig.* 1). This breaking away from the centre has been attributed largely to non-uniformity of the briquette, on the basis that the minimum section at the neck of the briquette contained more cement or sand of better grading than the larger sections above and below. However, it was noticed that in some cases the stronger briquettes broke in this fashion more frequently than the weaker ones. It seemed evident, therefore, that the real cause of such failure was due to something other than lack of uniformity. It is the purpose of this research to determine what changes could be made in the present procedure to prevent such eccentric breaks.

The stress distribution in the British briquette, which is practically the same as the United States standard, has been determined by Coker[1] and reported, in part, as follows : " As will readily be observed, the distinctive feature of the distribution in this case is an extremely variable longitudinal tension P across the section accompanied by a variable cross-stress Q of considerable magnitude in the transverse direction. In this British form, for example, with a load giving a mean average stress of 500 lb. per sq. in., the highest value of P at the outer contour is 870 lb. per sq. in., or 1·74 times the value of the mean stress, while it

Fig. 2.

Fig. 3.

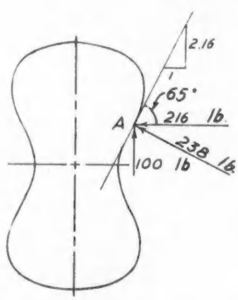

Fig. 4.

sinks to 405 lb. per sq. in. at the centre, or slightly more than 80 per cent. of the mean average value. In addition to this stress there is a cross-stress Q which rises rapidly from a zero value at the contour to a value of about 235 lb. per sq. in. for the central six-tenths of the cross-section, so that the manner of loading and

[1] E. G. Coker and L. N. G. Filon, " A Treatise on Photo-Elasticity," pp. 578–581, Cambridge University Press (1931).

the form of the section call into play a cross-stress of 47 per cent. of the mean average stress due to the pull. It is therefore seen that a member of this form is certainly not in pure tension, and the isochromatic bands which are observed on the model indicate this quite clearly. These results are applicable to American and Canadian Standards, since these forms are practically the same as the British Standard." The same author states that, according to its elastic properties, the cement briquette does not conform entirely to the transparent briquette but that any change made on the basis of the transparent or bakelite briquette will be more than satisfactory for the cement briquette, as ordinarily tested.

With the work of Coker as a guide, the principles of photoelasticity offered a means of studying changes in the form of specimen and changes in the present apparatus which would produce satisfactory test results.

Experiments Performed.

A full-size bakelite model of a standard cement briquette was placed in a photoelastic polariscope and subjected to a load of 400 lb. per sq. in., using the

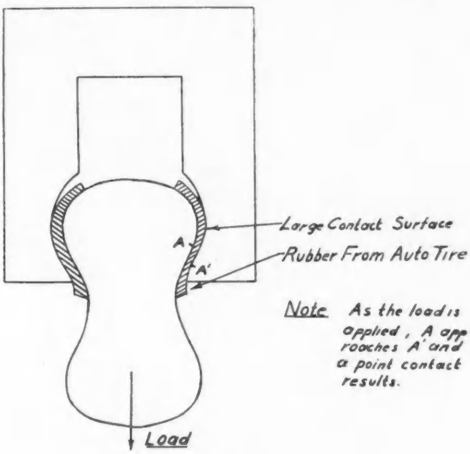

Fig. 5.

A.S.T.M. standard grips. *Fig.* 2, obtained without the quarter-wave plates, shows prominent dark areas over which the principal stresses were vertical and horizontal. It should be noted that over most of the centre portion the P stress is vertical.

With quarter-wave plates inserted, *Fig.* 3 resulted. The dark bands, isochromatics, indicate areas of equal shearing stress or areas in which the difference between the principal stresses (P-Q) is constant. Since the difference between (P-Q)'s for any two adjacent dark areas is 280 lb. per sq. in. and since at the boundary either P or Q is zero and P-Q = P or Q, some realisation of the magni-

tude of the stress in the vicinity of the roller bearing may be obtained directly. There are fourteen isochromatic bands radiating from the point of bearing. This indicates stresses of approximately 4,000 lb. per sq. in. at these points.

Mathematical analysis of conditions at the point of contact between grip and model will clearly indicate the cause for such high stresses (see *Fig.* 4). A tangent to the briquette at the point of contact makes an angle of about 65 deg. with the horizontal. Since the briquette and grip contact by means of a roller, the external forces acting on the briquette are always normal to the surface. It can readily be seen that any vertical force must be accompanied by a force normal to the surface of more than twice that amount and by a horizontal force

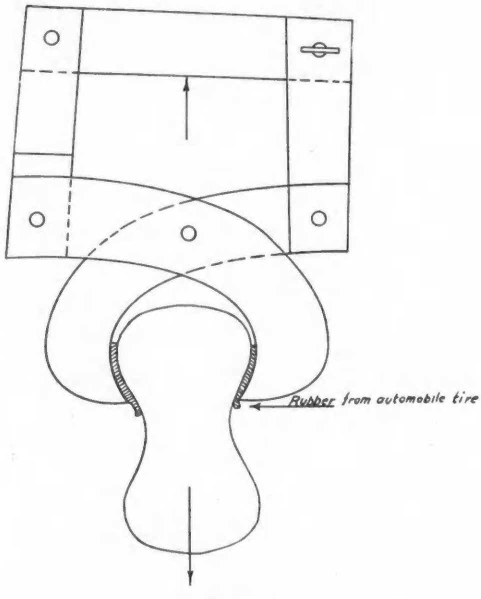

Fig. 6.

slightly less than the normal. It then appears that the roller bearing is the worst type of bearing which it would be possible to design. A grip was made similar to that shown in *Fig.* 5. This grip was a great improvement over the standard grip, especially under light loads, but with the type of rubber bearing used the higher loads caused the metal in the grip to penetrate the rubber and then, according to the photoelastic image, conditions were very nearly the same as with the standard. Next, a grip similar to that shown in *Fig.* 6 was made. This showed no worth-while improvements. The following analysis will indicate that probably the best type of grip should have a rubber bearing surface so hard that even at the maximum load the effect of the metal will not be felt on

the specimen and yet soft enough to develop a high coefficient of friction and to cause an even distribution of pressure.

As a load is applied to the briquette in *Fig.* 7, the rubber bearing surfaces are deformed and point A moves vertically downward. A force P_n will result, also a force P_t depending upon the flexibility of the rubber and the coefficient of friction between the rubber and concrete. Any coefficient of friction will produce results better than those produced by the roller bearing. If the proper kind of rubber is used so that the shearing deformation due to P_t equals $\frac{1}{2}P_n$, then the following relation of forces will exist, providing the coefficient of friction is 0·5 or more.

Assume $\theta = 65$ deg. Then from the sum of the vertical forces

$$P_v = 0{\cdot}423\,P_n + 0{\cdot}906\,P_t = 0{\cdot}876\,P_n \text{ since } P_t = \tfrac{1}{2}P_n$$

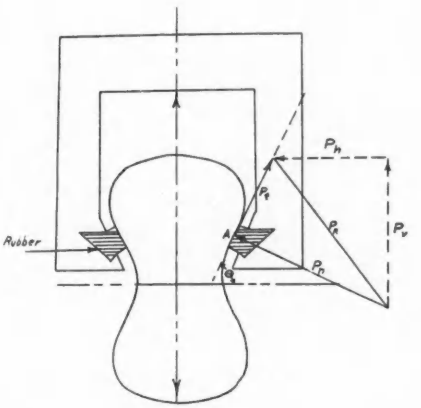

Fig. 7.

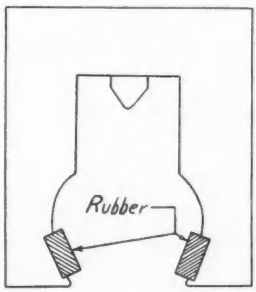

Fig. 8.

From the sum of the horizontal forces,

$$P_h = 0{\cdot}906\,P_n - 0{\cdot}423\,P_t = 0{\cdot}694\,P_n$$

$$P_h = 0{\cdot}8\,P_v$$

The corresponding values from *Fig.* 4 are $P_h = 2{\cdot}38\,P_v$

Hence it may be seen that, due to a load of 500 lb., the briquette will be subjected to a transverse load of 200 lb. as compared to 540 lb. for the present A.S.T.M. standard. The grip shown in *Fig.* 5 was modified as shown in *Fig.* 8. Several samples of rubber were obtained which varied in hardness from soft to fairly hard. Various samples were tried until one was found which eliminated any indication of stress concentration on the bearing surface. This is shown in *Fig.* 9.

The next problem was to smooth out the stress across the neck of the briquette. The distribution of vertical stress across the neck of the briquette using the standard grip (*Fig.* 3) is shown in *Fig.* 10, while the distribution for

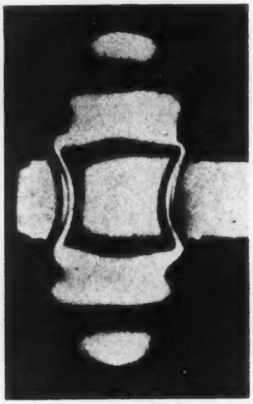

Fig. 9.

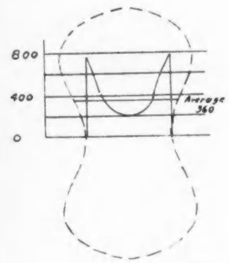

Fig. 10.

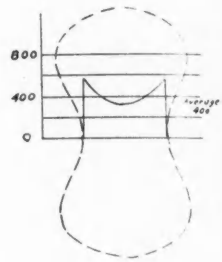

Fig. 11.

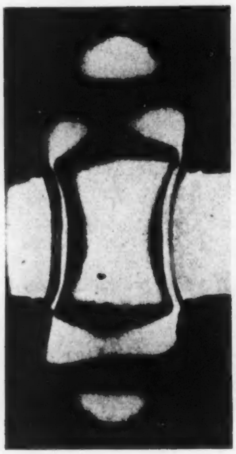

Fig. 12.

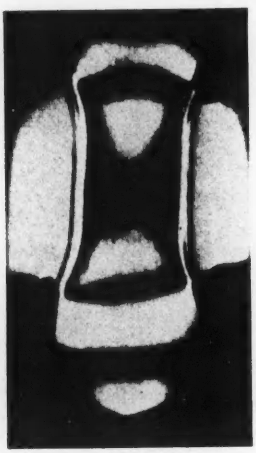

Fig. 13.

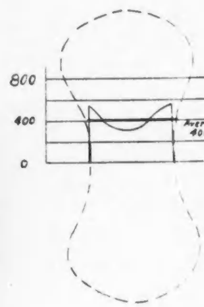

Fig. 14.

the modified form of grip (*Fig.* 9) is shown in *Fig.* 11. There is little practical difference; however, the rubber grip has caused some change for the better. *Fig.* 10 shows that, for the standard grip, the maximum stress at the edge is twice the average stress on a section at the centre, while *Fig.* 11 shows that, for the rubber grip, the maximum is about one and one-half times the average. These variations are somewhat greater than was expected from Coker's determination for the British briquette. They indicate that the tensile strength of Portland cement mortar is much greater than test results obtained from standard briquettes indicate.

Following these findings, two bakelite models were made similar to the standard except that one had a ½-in. uniform cross-section in the centre, while the other had

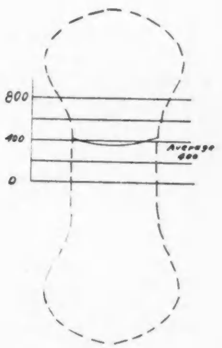

Fig. 15.

Fig. 16.

an extra 1 in. in the centre. The photoelastic results are shown in *Figs.* 12 and 13, while the variations in stress across the centre are plotted in *Figs.* 14 and 15.

Fig. 14 shows that the added ½-in. length caused some improvement in stress distribution. *Fig.* 15 shows that when 1 in. is added nearly perfect results are obtained. Because of the elastic properties peculiar to Portland cement mortar, the distribution of stress in the cement briquette is even more uniform than is indicated by the bakelite model. *Fig.* 16 shows that, in the central portion of the briquette, there is a large area over which the principal stresses are vertical and horizontal. Since there can be no horizontal stress at the boundary, there can be no horizontal component within this area and the stress is pure tension. Thus, the results obtained by using this form of test specimen and a type of grip similar to that shown in *Fig.* 8, will truthfully indicate the tensile strength of Portland cement mortar.

In carrying out these experiments it was noted that whereas the roller bearing permitted some adjustment of the specimen as tension was applied, the rubber bearing did not. Because of this lack of flexibility, in any machine constructed to make use of the findings herein recorded, the grip should be held securely instead of supported on a pivot. The rubber would then offer sufficient flexibility to permit the specimen to come to an upright position without causing uneven stresses.

The authors acknowledge the services rendered by Dr. Karl D. Larsen, Assistant Professor of Physics, in assisting with this investigation.

The Sampling of Materials for Cement Manufacture.

AN interesting article on the methods of controlling the raw materials used in the manufacture of Portland cement, by Mr. N. C. Rockwood, is published in the August 1940 number of *Rock Products*. The following is an abstract of Mr. Rockwood's article.

The May, 1940, issue of *Industrial Standards*, published by the American Standards Association, contains a review by Mr. John Gaillard of Walter A.

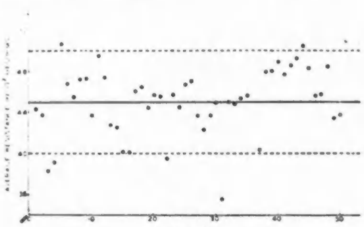

Fig. 1.

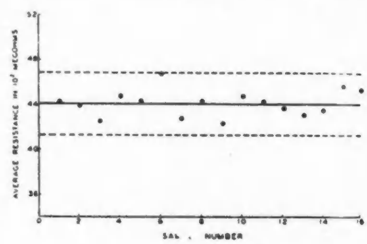

Fig. 2.

Shewhart's new book "Economic Quality Control of Manufactured Products," in which it is stated:

"A practical application based on experience is the control chart developed by Shewhart and his collaborators in the Bell Telephone Laboratories. *Fig.* 1 shows such a chart on which are plotted 51 averages of four resistance measurements each, made on 204 pieces of a new kind of product. The fact that several measurements fall outside the limits suggests lack of control. After certain causes of variability had been found and removed, the chart shown in *Fig.* 2 was made. Here, the measurements stay within limits narrower than those in *Fig.* 1. A narrowing of the limits is always accompanied by a rise in production

cost. Therefore, the manufacturer feels that since he has attained the control he wanted, why should he try to go further?

"From the standpoint of workshop practice, this reasoning is sound. But the manufacturer overlooks the fact that control of quality between narrower limits will enable him to make a more economic use of materials and component parts. The less confidence the engineer has in the control of quality of a material, the higher will be the 'safety factor' he adopts in his designs. Consequently, material is wasted in all cases where the safety factor could have been lower than the one adopted. Therefore, the savings made by more economic use of material may outweigh the higher cost of control between narrower limits. In traditional practice, the manufacturer probably does not think of this possibility due to the very fact that he is bent on using the widest possible tolerances compatible with good technical performance of his product. And if he does realise the advantage that may lie in a narrowing of the tolerance, he will not know how far he can go with a view to economy in production."

The quotations given, says Mr. Rockwood, form the barest outline of the statistical approach to quality control, but they are enough to show that tests of random samples of either raw materials or finished cement can be tabulated,

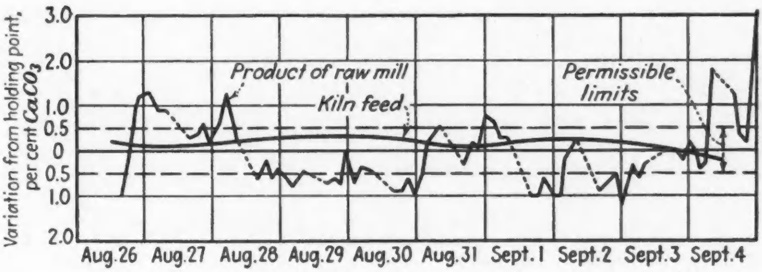

Fig. 3.

charted, and studied in such a way as to be of great assistance in quality control and in the determination of the causes of variations, some of which may be corrected.

We have heard of but one cement company which used this approach and that is the Universal Atlas Co., at its Leeds, Ala., plant. Four raw materials are used, namely, iron ore, sandstone, shale, and limestone. Proportioning of the crushed materials is done on automatic weighing belt scales. After raw grinding and classification the slurry is taken to Dorr Torq thickeners, from which the kiln feed-tanks are filled.

Sampling Slurry.

Mr. T. B. Counselman, of the Dorr Co., describing the method of control, said the striking feature of the Leeds plant is the complete absence of correction

tanks or large slurry-storage basins. Close chemical control on the basis of $CaCO_3$ content is carried out from the start of grinding. The bowl-classifier overflow is sampled automatically at the thickener, at four-minute intervals, and the accumulated sample is analysed every two hours. The variation from the holding point is determined, and the belt scales adjusted accordingly. These samples of bowl-classifier overflow show considerable chemical variation, but if the samples for a 24-hour or 48-hour period average at or near the holding point, the recircu-

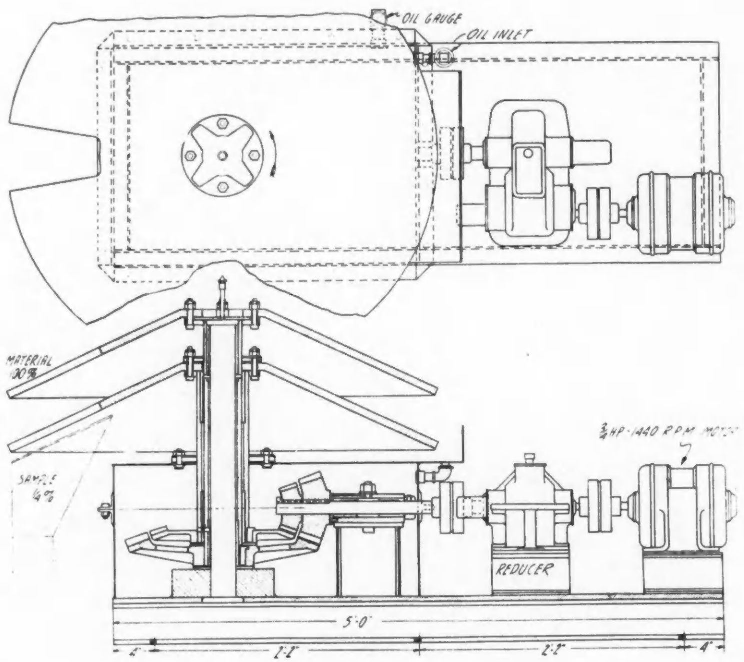

Fig. 4.—Twin-disc Sampler which deflects Material through openings in Discs placed directly over each other and Revolving at Different Speeds.

lation in the thickener will blend the material so that each kiln tank will be within the permissible limit of 0·5 per cent. variation from the holding point. *Fig. 3* shows the variation from the holding point of the feed to the thickener, and of the slurry withdrawn from the thickener during the same period. The smoothing effect of the recirculation is obvious. The importance of recirculation in the thickener, in order to get uniform chemical blending, cannot be minimised. Obviously, if there is no recirculation, the coarser high-lime and high-silica

particles tend to settle near the centre, while the shale particles, carrying the alumina, grind readily to the fine micron sizes and tend to distribute farther out in the thickener. If grinding were continuous a uniform mixture in the thickener underflow would be obtained. On a five-day-week grinding schedule, during non-grinding periods, if there is no recirculation, withdrawal at first tends to be high in lime and silica, coarse in particle size, and low in moisture. It is highly desirable to keep the slurry as uniform as possible. Blending by recirculation in the thickener has been found entirely practicable from the chemical standpoint.

The sampler used at the Leeds plant is a type well known in the mining industry. There are two or three other plants in the cement industry also equipped with it.

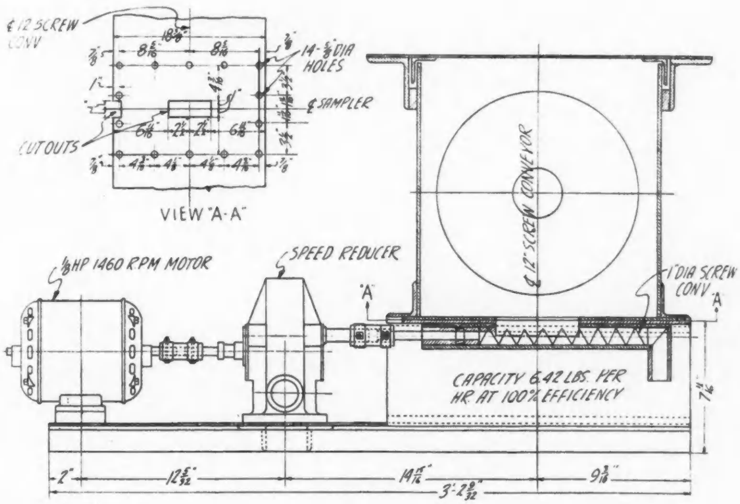

Fig. 5.—A 1-in. diameter Screw Sampler placed at right angles to a 12-in. Screw Conveyor.

Mr. T. A. Hicks, chemist of the Universal Atlas Company, describes it as follows: "A sampler, automatic in action, takes a cut through the slurry stream as it enters the thickeners and discharges this cut of slurry into a separate tank. The sampler is equipped with a mechanical device so that the number of cuts per hour can be regulated at will. It is our practice to take a cut of this slurry once a minute. At 24-hour intervals the slurry in the separate tank containing a composite of these cuts is thoroughly agitated with air and a sample is taken to the laboratory for analysis. We believe that such an installation delivers a very accurate composite sample as regards chemical constituents, particle size, or fineness."

Machine Sampling in the Metallurgical Industry.

The Allis-Chalmers Manufacturing Co. have had extensive experience in the mining and metallurgical field as well as in the cement industry. The following paragraphs are their contribution.

"In meeting new specifications the steps in manufacture must be under constant control, which means accurate and frequent sampling as well as the employment of process equipment which is easily and quickly adjusted. Accurate sampling machines have probably received most attention in metal mining and

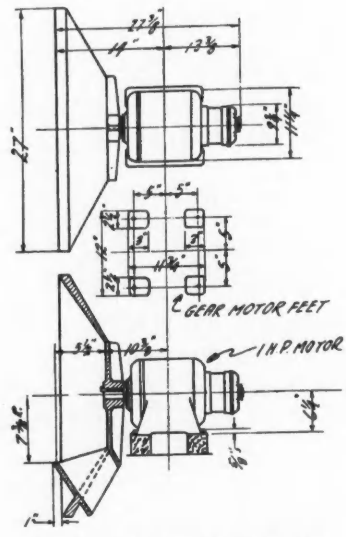

Fig. 6.—The Snyder Sampler.

ore concentration, where, on account of the high value of the materials handled and the invariability, sampling methods have been investigated and mechanical sampling has been developed to a high standard. Machine sampling is indicated where changes in a stream of material are fairly rapid, or where close control is needed, and where frequent samples are required. If the cost of hand sampling becomes excessive, then sampling by machine is indicated.

"Samplers such as the Snyder or Vezin samplers may be placed in a stream of raw materials being delivered to storage, all of which has been reduced to about 1 in. maximum size. The Snyder sampler consists of a pan-shaped plate, revolving in a vertical plane, mounted on a horizontal slow-speed shaft of a gear-motor. The plate has one or more sampling openings or spouts. As the plate revolves the spout deflects for the sample such portion as the arc of the spout bears to the circle of revolution. At other times the material strikes the plate and is thrown back

to the feeding stream. The machine is simply constructed, easily cleaned and repaired, and can be observed in operation.

"The Vezin sampler consists of two hollow truncated cones, joined base to base, with one or more scoops attached to the upper cone, all mounted on a vertical shaft. As the sampler revolves, the scoops divert part of the material stream into the conical chamber. Vezin samplers are capable of taking a correct and accurate cut of a stream of dry material. The cutting edges of this sampler are usually radial to the axis of rotation so that all points have the same angular

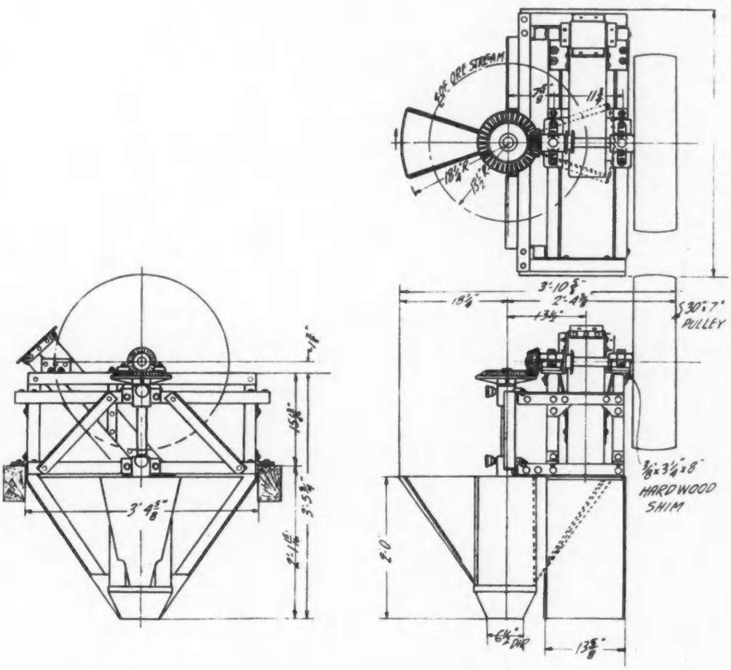

Fig. 7.—The Vezin Sampler.

velocity and pass through the material stream for the same time. The quantity of sample obtained in the instance given above would probably have to be reduced further by hand or by one or more samplers in series. Splitters or riffles might be used to reduce the quantity of sample.

"Another sampler which has been proposed for compeb mill or preliminator feed consists of twin discs shaped like inverted pans, placed directly over each other, and revolving at different speeds. Each disc has a rectangular section cut out, one side of this opening being at the periphery of the disc. Both openings

coincide at such intervals as to give a sample of 0·25 per cent. of the material fed to the top disc.

"For pulverised materials handled in screw conveyors, a 1-in. diameter sampling screw placed at right angles to the conveyor and directly beneath it will extract a continuous sample though not necessarily a representative sample of the material in the screw conveyor.

"Dry pulverised materials in chutes, such as discharge from grinding mills, can be sampled by a vane which oscillates on a shaft and deflects the stream for a fixed period into a sampling chute. The flow must be concentrated into a thin stream by means of a spout above the edge of the vane. This device takes more from one side of the stream than the other, but in the instance of a mill discharge the material might be considered quite uniform. Samples of pulverised materials may be taken from a moving conveyor belt by small cups which dip into the layer on the belt at intervals along the length of the belt, each cup cutting part of the cross-section. The sample thus taken is not representative of the mass, but may be useful where more elaborate and accurate means are not justified.

"Raw materials in preparation, in the wet process, either as pulp or slurry, may be readily sampled by cutting across the flow in a pipe or flume. One device which, it is claimed, fulfils all requirements for accurate machine sampling, is well known in ore milling, and may be used for raw pulp and slurry from thickeners, classifiers, mills, blending tanks, flotation circuits, etc. The machine is placed at the discharge of a pipe or flume so that the cutter takes a complete cross-sectional slice of the stream. The vertical cutter is fixed to a bar, which is part of a cross-head. The latter moves horizontally on a threaded shaft operated by a small synchronous motor. The cutter moves across and completely out of the stream at each cut. The motor is reversible and operates intermittently at intervals regulated by an electric timing switch. The sample is collected in any desired way through a removable spout attached to the lower portion of the cutter. Cutters may be designed with the cutting slot suitable for the material being sampled. Dry pulverised material flowing over a conveyor pulley or from a chute may be sampled by this type of sampler, but it is generally applied to slurry and pulps.

"Splitters may be used to halve the sample, the reject of which is returned to the main stream."

Methods of Proportioning Raw Materials.

A discussion on methods of proportioning the raw materials used in Portland cement manufacture is given by Mr. N. C. Rockwood in "Rock Products" for August, 1940. The following is an abstract of Mr. Rockwood's article, which deals particularly with the more accurate methods of proportioning which will be necessary in the manufacture of cement to the requirements of the new United States specifications.

The problem now to be met was solved to its own satisfaction by the Missouri Portland Cement Co. at its Prospect Hill (St. Louis) plant in 1935. Changes in the raw material department were made to handle four raw materials in addition to limestone. To provide accurate proportioning, two cylindrical concrete silos nearest the skip hoist were cut off at their middle, new bottoms were placed, and the room below them thus created was used to place the feeders, batchers and the mix conveyor. One of these half-silo bins holds limestone; the other is divided into four compartments for shale, iron ore, fire clay and fluorspar. The limestone is withdrawn from its bin by a pair of steel apron feeders to a weighing batcher; the other four materials are withdrawn by adjustable table feeders to a three-material weighing batcher. The plant is arranged to weigh either two or three materials into the same batch hopper automatically, and is mounted on wheels so that it may be shifted under either of two sets of table feeders mounted under the material silos. The table feeders discharge into chutes, which extend to within approximately 6 in. of the weighing hopper. The batcher is equipped with a clam-shell discharge gate operated by a 1 h.p. geared-head motor. It is supported on an overhead hopper scale, equipped with three charging beams and one empty beam box, which is also equipped with electrical contacts. The indicator is connected to the scale beam through an equalising bar in such a manner that when the counterpoises are set for a given batch, the indicator will show balance at the full position when the proper amount of material is in the hopper and will come to balance at empty when the material has been fully discharged. The materials are batched into the hopper consecutively, the proper table feeder being started and stopped, and the proper scale beam being thrown in and out of action, by means of a thrust-operated mechanism which includes a drum switch to change over the electrical connections operated by cam and ratchet mechanism, which also operates the scale beam locks.

Three-Material Batcher.

When the discharge gate is closed, the table feeder handling the first material to be weighed is automatically started. This material is weighed on the first or upper beam in the scale box, and, as the second and third beams have been automatically locked when the discharge gate was previously opened, the material is fed into the hopper until the scale comes to balance at a weight corresponding to the setting of the first counterpoise. When the scale comes to balance with the first material being weighed in the hopper, the first table feeder is automatic-

ally shut off and the second table feeder automatically started, the second scale beam also being automatically unlocked, allowing it to come into action so as to weigh the second material. When the second material brings the scale to balance, the second table feeder is shut off and the third table feeder started automatically and at the same time the third scale beam is unlocked. When the third material is weighed and the scale comes to full balance the thrustor and drum switch mechanism automatically moves to its fourth, or discharge, position. The batcher is discharged by a clock-operated switch which makes a contact every two minutes, but material cannot be discharged unless the drum switch is at the fourth, or discharge, position. When only two materials are being weighed the operation is the same except that the thrustor and drum switch mechanism moves directly from position No. 2 to position No. 4 immediately after the second material has been weighed.

Limestone Batcher.

The limestone batcher is filled by means of two apron feeders located directly under the material silo and driven by a common motor and speed reducer. As the hopper is rectangular in shape, the use of two feeders with discharge spaced approximately 4 ft. apart ensures the most economical use of the hopper capacity as it is possible to fill the hopper practically level without any spilling; it holds 10,000 lb. The scale is of the same general type as described for the three-material batcher except that there is only one charging beam and one empty beam. The two apron feeders are automatically started when the discharge gate is closed and the material is fed into the hopper until the electric contact in the scale indicator is closed at the predetermined cut-off point. The discharge gate is of the clam-shell type operated by a 2 h.p. geared head motor and a dead-centre crank mechanism similar to that on the three-material batcher. The electrical control box is also similar to that on the three-material batcher with the exception that the switch is adjusted for a two-minute total cycle.

The batchers are so interlocked that, when the clock makes contact at the end of two minutes, both batchers are discharged simultaneously. If one of the batchers has not been filled to the correct weight, neither batcher will be discharged until the clock again makes contact, the batcher having been filled during the interim. Both batchers are equipped with a tell-tale relay and indicating lamp, which is placed at a convenient point so that the supervisor may know that the batchers are functioning properly. The lamps light when the batchers are full and go out when they are empty. The operation of these batchers is fully automatic, requiring no attendant for their continuous operation.

The table feeders are 6 ft. in diameter. Two adjustments are possible: (1) The inlet pipe column may be raised or lowered; (2) the angle of the plough may be changed by a hand screw.

Gravimetric Feeders and Proportioners.

Gravimetric feeders, of the conveying-weigher type, which automatically record the weight of the material being delivered, are commonly used to feed

raw materials to dry grinding mills. One machine each, for limestone and clay, are usually employed for one mill. The speed of delivery of each feeder is controlled to maintain a proportional rate of feed as is indicated by routine chemical analysis. By connecting the scale with a device which regulates the discharge from the storage bin, delivery at a constant predetermined rate may be maintained. These continuous weighing devices may be driven by direct-current motors through a gear reducer. Each machine has a rheostat so that the proportioning relation may be changed. A main rheostat controls the speed of both machines so that the total amount of material delivered may be regulated, the proportions remaining constant. Maintenance cost on these machines is low and they require little attention except when adjustments are made. They occupy small space, and when kept in proper adjustment they may be accurate to 0·5 per cent.

Ferris-wheel feeders are accurate and relatively simple feeding devices which may be used to feed clay slip to raw wet grinding mills. In such service they may be electrically synchronised with the limestone feeder to deliver a predetermined quantity. A ferris-wheel feeder consists of a tank containing the feed with bearings for a slow-speed horizontal shaft on which is mounted a circular disc with buckets affixed to its periphery, the buckets dipping into the clay slip and, on arriving near their highest point of travel, spilling into a funnel and pipe leading to the mill. The amount of feed is regulated by the number of U-shape buckets mounted on the disc, by changing the angle of dip of one or more of the buckets, by changing the rotating speed of the disc, or by a combination of two or more of these variables. The tank is provided with an overflow pipe which returns the excess clay slip to the clay storage tank.

A constant orifice feeder for pulp and slurry, which consists of a valve with a square opening, is also applicable for the feeding of clay slip to mills. A sliding plate regulates the flow and maintains, in all positions, the square opening. Since the shape of the orifice remains the same, the viscosity of the material remaining the same, the discharge varies directly as the area, and may be easily calibrated and controlled.

Gravimetric conveying-weigher feeders are being more commonly employed in clinker grinding. Perhaps the reason for this is that modern clinker grinding departments wish, in some cases, to produce predetermined amounts of various kinds of cement in the same mill. Gravimetric feeding devices may be used to record the quantities of clinker delivered and show the operator what quantity of a particular cement has passed through the mill. He may adjust or change his grinding circuit or rate of feed to produce cement of another specification when a desired quantity has been made.

Table Feeder Controls.

Table feeders are widely used for the feeding of clinker and gypsum to cement grinding mills. While they make no record of the amount of material fed they are easily calibrated and adjusted and provide a method of proportion control. A usual form incorporates two tables in one machine, each table driven

at relative speeds appropriate for the simultaneous feeding of clinker from one and gypsum from the other. The material is fed to the centre of the revolving table and an adjustable arm cuts the base of the flat cone thus formed. Both tables discharge to a common chute. After it has been calibrated, the table feeder requires a minimum of attention and maintenance. A direct-current gear-motor may be applied to drive the unit, regulation being made through a single rheostat.

Several methods of feeding cement slurry to rotary kilns are employed. Probably the most widely used is the ferris-wheel type feeder, due to its simplicity, accuracy and dependability. The earliest installations of this type of feeder were among the first wet-process cement kiln installations, and were driven from a line shaft by belts or from the upper end of the kiln by a chain drive. The design and method of drive have been improved, but the principle remains the same. The modern ferris-wheel feeder consists of a slurry tank fitted with an overflow pipe to maintain a constant level of slurry, into which the ferris-wheel is usually overhung on the low-speed shaft of a gear reducer. The gear reducer is connected to a small alternating-current motor through a speed-adjusting device to provide adjustment of the quantity delivered. The feeder may be synchronised with the kiln by the use of a small alternating-current generator driven by the main kiln motor or by the high-speed shaft of the gear reducer. In cases where an adjustable-speed direct-current motor is used to drive the kiln, the alternator supplying the feeder motor may be connected to an extended shaft of a kiln motor. In cases where a constant-speed alternating-current motor is used, a speed-adjusting device is used between the drive motor and the kiln gearing, in which case the small alternating-current generator must be driven from the variable-speed shaft.

Applicable to the feeding of dry process kilns is a patented device consisting of a double-screw feeder in which a hardwood "choker block," maintained by springs against the upper portion of the conveying flights, prevents flooding or flushing of the finely pulverised raw material. That part of the feeder directly beneath the bin contains a section of flights tapering toward the feed end. Stirrers are attached to this section, these being of slightly larger diameter than that of the main screw section. A single countershaft, to which may be connected a variable-speed drive, operates both screws through a built-in countershaft box.

More accurate proportioning of raw materials to make clinker, and of various types of clinker to make cement, will necessarily involve more accuracy in feeding mills and kilns, because uniformity in grinding and uniformity in burning appear to be as effective in determining physical characteristics of Portland cement as its chemical or mineralogical ingredients. It will also involve better methods of sampling.